Deliverable number: D3.2
Deliverable title: Interim results of the pilot projects in terms of achieved emission reduction

Document ID: uCARe-D3.2-v2.0
Dissemination level: Public
Main Author: Savas Geivanidis
Issue date: 26-11-2020
Disclaimer and acknowledgement

This project has received funding from the European Union's Horizon 2020 Programme Research and Innovation action under grant agreement No 815002

Disclaimer

This document reflects the views of the author(s) and does not necessarily reflect the views or policy of the European Commission. Whilst efforts have been made to ensure the accuracy and completeness of this document, the uCARe consortium shall not be liable for any errors or omissions, however caused.

uCARe consortium

[Logos of all consortium members]
## Document information
### Additional author(s) and contributing partners

<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paschalis Bidios</td>
<td>Aristotle University</td>
</tr>
</tbody>
</table>

## Document Change Log

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>v0.1</td>
<td></td>
<td>First draft of document</td>
</tr>
<tr>
<td>v0.2</td>
<td></td>
<td>Revised version based on the comments of Sonja Forward (VTI) and Samantha Jamson (UnLe)</td>
</tr>
<tr>
<td>v1.0</td>
<td></td>
<td>Revised version based on the comments of Paul Tilanus (TNO)</td>
</tr>
<tr>
<td>v2.0</td>
<td></td>
<td>First final version, approved by Executive Board, (will be) submitted to EC.</td>
</tr>
</tbody>
</table>

## Document Distribution Log

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Distributed to</th>
</tr>
</thead>
<tbody>
<tr>
<td>v0.1</td>
<td></td>
<td>Samantha Jamson, Sonja Forward</td>
</tr>
<tr>
<td>V0.2</td>
<td></td>
<td>Paul Tilanus</td>
</tr>
<tr>
<td>V2.0</td>
<td></td>
<td>Paul Tilanus</td>
</tr>
</tbody>
</table>

## Verification and approval

<table>
<thead>
<tr>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verification Final Draft by WP leader</td>
<td>26-11-2020</td>
</tr>
<tr>
<td>Check before upload by coordinator</td>
<td>26-11-2020</td>
</tr>
</tbody>
</table>
Executive summary

This report presents the first three pilot activities carried out within uCARe. These activities were carried out as such in order to overcome the restrictions introduced so far by the COVID-19 pandemic. The restrictions include ban of all exercises requiring gathering of groups of people. At the same time restrictions reduce the number of trips performed by drivers and mileage accumulation of vehicles in general.

As regards Pilot 1, it aimed in collecting data from drivers before and after being educated in methods for improving the emission performance of their vehicles by altering their driving style. The pilot was run in parallel to another yearly held event in the city of Serres/Greece to ensure that authorities and local community will endorse its execution since the main event and with the permission of the local secondary education authority. The target group consisted of parents driving students to the summer school and waiting in the premises of the summer school to collected students back to home. This first pilot failed due to the reluctance of drivers to allow people to enter their cars and install equipment due to the fear of being exposed to risk of infection with COVID-19. Some participants stated that they considered the activity not that motivating to them to take any risk. It was concluded that drivers being interested in uCARe does not necessarily mean that they would ever participate in a pilot programme or citizen science exercise. An application or device giving results onboard the vehicle would trigger interest to install and use uCARe equipment. It was also concluded that willingness of drivers to install equipment on their vehicles should be secured prior to starting any activity in order to minimize the risk of failure. All observations and experiences collected during this unsuccessful fort pilot are taken into account in future pilot activities within uCARe.

As regards Pilot 2, an emission assessment performed within uCARe using results from both simulations with software and emission data collected from measurements on the road using PEMS from trips with similar traffic conditions. A car was driven using three different driving styles along the same route. The driving styles were defined using the journey’s average product of vehicle velocity and positive acceleration. The car was equipped with portable emission measurement equipment that measured and recorded vehicle emissions in real time. In addition, vehicle operation data were recorded from the on-board diagnostic system of the car. The latter were inputted to the uCARe model to assess the emission performance of the car by simulation. Measurement and simulation results were compared to assess the effect of vehicle dynamics on emissions as well as the accuracy of model simulation. It was concluded that, in general, simulation leads to higher emissions compared to measurement for both CO and NOx with no consistent trend related to the three driving styles. A cold start effect should be added in the model and further explored as regards its effect on simulation accuracy. Model behaviour and performance is being further explored over a wider range of vehicles to arrive to safe conclusions as regards the accuracy of the model and the effect of driving style on emissions. From the outcome of the use of the first version of the uCARe tool it is concluded that the uCARe tool is able to fulfil the needs of uCARe that is the simulation of the emission performance of vehicles using vehicle operation data possible to be derived from the standard OBD data port available in all vehicles in the market. Although the accuracy of the outcome is limited, it is already sufficient for providing an insight on the effects of improved driving have on the reduction of emissions produced by vehicles. The uCARe tool, being in its first version, is in any way planned to have an improved version as more modules and data are added. In addition, further improvement is expected to be introduced by resolving the open issues revealed in pilot 2.

As regards the Pilot 3, it comes as a workaround to the issues that the restrictions of the current COVID-19 pandemic induce as well as the shortcomings of pilot 1 in Serres. The way it is structured it is expected to secure a first real-world experience. It will build upon the synergy with MILE21 project to take inboard uCARe MILE21 drivers have already been employed in installing equipment on their vehicles to collect data in real world operation. The stepwise approach will ensure collection of all data needed in terms of vehicle operation and driver perception at the same time at each phase of execution. The stepwise structure includes safety
measure to ensure resolution of problems that may arise during the evolution of pilot 3. Pilot 3 is ongoing and results are expected by end of January 2021.
Table of contents

Executive summary .................................................................................................................. 4
Table of contents .................................................................................................................... 6
List of Figures ........................................................................................................................ 7
List of Tables .......................................................................................................................... 7
Definitions & Abbreviations ................................................................................................. 8

1 Introduction .......................................................................................................................... 9
  1.1 Background to the uCARe project ................................................................. 9
  1.2 Purpose of the document .................................................................................. 10
  1.3 Document Structure ......................................................................................... 10
  1.4 Deviations from original DoW ........................................................................ 11
    1.4.1 Description of work related to deliverable as given in DoW ..................... 11
    1.4.2 Time deviations from original DoW ......................................................... 11
    1.4.3 Content deviations from original DoW .................................................... 11

2 Pilot 1: Change of environmental performance after education of drivers in Serres ...... 12
  2.1 Introduction .......................................................................................................... 12
  2.2 Methodology ......................................................................................................... 12
    2.2.1 Support and venue ................................................................................... 12
    2.2.2 Structure of the pilot in Serres ................................................................ 12
  2.3 Results and discussion ......................................................................................... 13

3 Pilot 2: Assessment of driving performance metrics derived using the first version of the uCARe tool on data collected with different driving styles ........................................... 14
  3.1 Introduction .......................................................................................................... 14
  3.2 Methodology ......................................................................................................... 14
    3.2.1 Vehicle and drivers .................................................................................. 14
    3.2.2 Driving dynamics specifications and route ............................................... 15
    3.2.3 Data input description ............................................................................. 16
  3.3 Results and discussion ......................................................................................... 20
    3.3.1 Comparison of emission performance in g/km ........................................ 21
    3.3.2 Correlations ............................................................................................ 23
    3.3.3 Cumulative results .................................................................................. 25
    3.3.4 Conclusions ........................................................................................... 27

4 Pilot 3: Change of environmental performance after education of drivers in synergy with MILE21 .................................................................................................................. 28
  4.1 Introduction .......................................................................................................... 28
  4.2 Methodology ......................................................................................................... 28
  4.3 Results and discussion ......................................................................................... 29

5 Appendix ....................................................................................................................... 30
  5.1 Additional emission results from measurement and simulations ....................... 30
5.1.1 Petrol .................................................................................................................. 30
5.1.2 CNG .................................................................................................................. 33
References .................................................................................................................. 36

List of Figures
Figure 1: Velocity multiplied by positive acceleration and driving styles ..................... 15
Figure 2: Route Altitude and velocity profile to distance travelled ............................... 16
Figure 3: .veh file inputs ............................................................................................ 16
Figure 4: .dri file template ......................................................................................... 17
Figure 5: Petrol gram per kilometer comparison ....................................................... 21
Figure 6: CNG gram per kilometre comparison ......................................................... 22
Figure 7: Correlations Petrol .................................................................................... 23
Figure 8: Correlations CNG ...................................................................................... 24
Figure 9: Cumulative Petrol emissions ...................................................................... 26
Figure 10: Cumulative CNG emissions .................................................................... 26
Figure 11: Petrol REG CO second by second comparison ......................................... 30
Figure 12: Petrol REG NOx second by second comparison ....................................... 30
Figure 13: Petrol DYN CO second by second comparison ......................................... 31
Figure 14: Petrol DYN NOx second by second comparison ....................................... 31
Figure 16: Petrol eDYN CO second by second comparison ....................................... 32
Figure 17: Petrol eDYN NOx second by second comparison ....................................... 32
Figure 19: CNG REG CO second by second comparison .......................................... 33
Figure 20: CNG REG NOx second by second comparison ........................................ 33
Figure 22: CNG DYN CO second by second comparison .......................................... 34
Figure 23: CNG DYN NOx second by second comparison ........................................ 34
Figure 25: CNG eDYN CO second by second comparison ........................................ 35
Figure 26: CNG eDYN NOx second by second comparison ....................................... 35

List of Tables
Table 1: Test vehicle information ............................................................................. 15
Table 2: Number of available cycles ........................................................................ 20
Table 3: Available simulations ................................................................................. 20
### Definitions & Abbreviations

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNG</td>
<td>Compressed Natural Gas</td>
</tr>
<tr>
<td>CO</td>
<td>Carbon monoxide</td>
</tr>
<tr>
<td>COPERT</td>
<td>COnputer Programme to calculate Emissions from Road Transport</td>
</tr>
<tr>
<td>DYN</td>
<td>Dynamic, driving route performed just below the upper limit of driving conditions dynamics of RDE testing regulation</td>
</tr>
<tr>
<td>eDYN</td>
<td>Extra-dynamic: driving route performed above the upper limit of driving dynamics of RDE testing regulation</td>
</tr>
<tr>
<td>MILE21</td>
<td>More information less emissions, Empowering Consumers for a Greener 21st Century, project co-financed by the LIFE+ program of the European Union, under agreement number: LIFE17 GIC/GR/000128</td>
</tr>
<tr>
<td>NOx</td>
<td>Nitrogen Oxides</td>
</tr>
<tr>
<td>PHEM</td>
<td>Passenger car and Heavy-duty Emission Model</td>
</tr>
<tr>
<td>RDE</td>
<td>Real Driving Emissions</td>
</tr>
<tr>
<td>REG</td>
<td>Regular, driving route performed with driving dynamics within the specifications of RDE testing regulation</td>
</tr>
<tr>
<td>uCARe tool</td>
<td>Model that calculates vehicle emissions using as input parameters recorded from the OBD data port of the vehicle</td>
</tr>
<tr>
<td>vma</td>
<td>Velocity multiplied by positive acceleration</td>
</tr>
</tbody>
</table>
1 Introduction

1.1 Background to the uCARe project

With four million people dying annually due to outdoor pollution, improvement of air quality has become one of society's main challenges. In Europe, traffic and transport have a large effect on air quality, specifically passenger cars and commercial vehicles and to a lesser extent non-road mobile machinery. While technical improvements and more stringent legislation have had a significant impact, traffic and transport emissions are still too high and air quality is still poor. Although the use of electric and other zero-emission propulsion technologies may drastically reduce the pollutant exhaust emissions from traffic, the slow introduction of such vehicles as well as the trend of increasing vehicle lifetimes means that vehicles with internal combustion engines are expected to dominate the fleet beyond 2030. This project is the first opportunity to improve emissions of vehicles, not by improving vehicle technology, but by actively involving vehicle users and enabling their contribution to clean driving.

So far, expertise on pollutant emissions has mainly been used to advise European policy makers on limited effectiveness of emission legislation (through real-world emission factors such as HBEFA [1] and COPERT [2]) and how to reduce traffic and transport pollutant emissions. The numerous mitigation methods are rarely extended to include the perspectives of users uCARe enables a next essential step: providing user targeted emission reduction measures. These measures will be implemented and evaluated in real-life pilot projects.

The overall aim of uCARe is to reduce the overall pollutant emissions of the existing combustion engine vehicle fleet by providing vehicle users with simple and effective tools to decrease their individual emissions and to support stakeholders with an interest in local air quality in selecting feasible intervention strategies that lead to the desired user behaviour. The overall aim is accompanied by the following objectives:

1. To identify user-influenced vehicle emission aspects (such as driving behaviour and vehicle component choice).
2. To determine the emission reduction potential of each vehicle emission aspect with help of the uCARe model developed within a toolbox.
3. To develop a toolbox, containing models and emission reduction measures, that enable stakeholders to identify the most appropriate intervention strategies that reflect the specific users and their motivation.
4. Support policy makers and other stakeholders with an interest in air quality, such as municipalities and branch organizations, in identifying intervention strategies that translate the measures into desired behaviour of the user.
5. To test and evaluate intervention strategies in a set of pilot projects conducted with various target user groups in at least four European countries. The pilot projects illustrate effectiveness and feasibility of the toolbox and intervention strategies developed on its basis.
6. Perform an impact assessment of the intervention strategies effectiveness, in terms of cost, penetration, achieved emission reduction and lasting effects.
7. Actively supply European cities and international parties with uCARe learning and results, via awareness raising campaigns, communication tools, interactive web application and other dissemination activities. Open access to the broad public to the toolbox, data and developed tools.
8. Summarise the findings in blueprints for rolling out different user-oriented emission reduction programmes, based on successful pilots.

This document reports the interim results of the pilot projects in terms of achieved emission reduction during the execution of the pilot projects. These results will serve as a quantitative index for the evaluations within WP3 and WP4. The conclusions of this report express emission reductions in both absolute terms (i.e. mass of pollutant saved) as well as relative terms (i.e. percentage of pollutant saved over the non-optimal driver behaviour). This is a live document with results being added in incremental versions of the document during the execution of pilots.
1.2 Purpose of the document

The purpose of this document is to present the results of the pilot projects in terms of achieved emission reduction. In addition, all methodological elements undergo evaluation before the selection of them to be included in the intervention strategies of the project. The latter include advice to the drivers, educational material as well as emission modelling tools either in the form of a methodology or in the form of an application in software.

The aim of uCARe is to reduce the overall pollutant emissions of the existing vehicle fleet by providing vehicle users with simple and effective tools to decrease their individual emissions and to support stakeholders with an interest in local air quality in selecting feasible intervention strategies that lead to the desired user behaviour. In this report will include the analysis of uCARe measures, strategies and tools for the determination of the model accuracy and the effects on emission performance of vehicles.

All outputs of this report are produced and presented in a way to be directly used by WP4 to extrapolate the performance of the elements and tools and assess the effect at vehicle fleet level. Outputs are produced and presented in a way to serve the needs of emission modelling in real world conditions.

This deliverable is a dynamic document, i.e. when a new pilot is conceived and, in some cases, performed or an evaluation of methodological element of the project is completed, it is evaluated and results are added to the document. The full version will be available close to the end of the project.

1.3 Document Structure

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Purpose of the document</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 1</td>
<td>Introduction</td>
</tr>
<tr>
<td></td>
<td>This chapter provides brief background to the project, overall objectives of the project, and work package specific background.</td>
</tr>
<tr>
<td>Chapter 2</td>
<td>Pilot 1: Change of environmental performance after education of drivers in Serres</td>
</tr>
<tr>
<td></td>
<td>This chapter provides a description of pilot 1, the methodology followed as well as a discussion of the results and experiences of this pilot.</td>
</tr>
<tr>
<td>Chapter 3</td>
<td>Pilot 2: Assessment of driving performance metrics derived using the first version of the uCARe tool on data collected with different driving styles</td>
</tr>
<tr>
<td></td>
<td>This chapter provides a description of pilot 1, the methodology followed as well as a discussion of the results and experiences of this pilot.</td>
</tr>
<tr>
<td>Chapter 4</td>
<td>Pilot 3: Change of environmental performance after education of drivers in synergy with MILE21</td>
</tr>
<tr>
<td></td>
<td>This chapter provides a description of pilot 1, the methodology followed as well as a discussion of the results and experiences of this pilot.</td>
</tr>
</tbody>
</table>
Chapter 5 Appendix

This last chapter provides additional emission results from measurement and simulations performed within pilot 2.

1.4 Deviations from original DoW

1.4.1 Description of work related to deliverable as given in DoW
This deliverable aimed to provide the results of the assessment of the first pilot project(s) in terms of achieved emission reduction.

1.4.2 Time deviations from original DoW
This deliverable is submitted two months after the planned date.

1.4.3 Content deviations from original DoW
There are no content deviations in the sense that the available results of the assessment is presented as planned.

However, the initial aim was to present not only results for the assessment of emission tools but also results of at least one pilot within this interim deliverable and then to be updated as more pilots are executed. Due to the COVID-19 pandemic, several actions have either being modified or delayed. More specifically:

- Focus group meetings were not possible to be performed. For more information see deliverable 3.3.
- Pilot projects were not executed due the COVID-19 retention measures and the hesitation of stakeholders to hold such activities. As a workaround a pilot was compiled to be performed with existing material in parallel to an activity already permitted by local authorities in the city of Serres, Greece.

The report will be updated upon availability of data and the completion of any of the pilot projects to be performed within uCARe.
2 Pilot 1: Change of environmental performance after education of drivers in Serres

2.1 Introduction
A pilot with existing material was planned to be performed with the support of authorities within the framework of another local activity supported by the State in Greece and therefore allowing legally the meeting of a group of people under certain restrictions. The pilot was executed within the framework of an already scheduled summer school that was organised by authorities in cooperation with local stakeholders on 2-4 September in the city of Serres in Greece.

This pilot aimed in collecting data from drivers before and after being educated in methods for improving the emission performance of their vehicles by altering their driving style. These data were planned to be used for the evaluations within this deliverable. The pilot was run in parallel to the main event and with the permission of the local secondary education authority. The target group consisted of parents driving students to the summer school and waiting in the premises of the summer school to collected students back to home. Parents participated in this pilot during their waiting period.

2.2 Methodology

2.2.1 Support and venue
The first pilot in Serres was endorsed and supported by:

- Car and Motorcycle Club of Serres
- Directorate of secondary education
- Club Serres for UNESCO
- Department of Environment, Municipality of Serres
- Vehicle Technology Laboratory (VTL) (International Hellenic University, IHU)

It was held in the outdoors assembly space of the racing circuit of Serres (80 km from Thessaloniki, Greece).

2.2.2 Structure of the pilot in Serres
The structure of the pilot in Serres included training, demonstrations, trip recordings, emission evaluation, final interviews distributed over three days as follows:

On day one, participants are informed of the project objectives and of the equipment they have to install on their vehicles to start collecting data before being informed of emission improvement techniques. Following that, they will collect vehicle operation data using OBD dongles installed on their vehicles. The dongles should at least collect vehicle operation data (engine nd vehicle speed) on the trip from the summer school premises to home and next morning’s trip from home to summer school.

On day two, the plan is to educate drivers in emission performance driving techniques and continue collecting data on the same trips as in day one but with the advice to change their driving style.

On the third day, data are downloaded from the data acquisition equipment. The evaluation of data is to be performed using commercial emission models available in uCARe partners or the uCARe tool.

Finally, drivers are informed of the outcome of their driving improvement efforts within a week of completion. In addition, participants are asked whether they would like to continue recording the daily trips for the collection of additional data and the evaluation of their gradual change in driving style.
2.3 Results and discussion

This first pilot failed due to the reluctance of drivers to allow people to enter their cars and install equipment. The discussion with participants revealed that the main drive behind their reluctance was that they did not want to risk infection with COVID-19. Although the equipment was simple consisting only of a dongle to hook their car, a technician had to make the first-time installation and a contact with vehicle cabin was inevitable. The reluctance was not as intense to all participants but the stance of the more unwilling quickly affected all. It has to be noted that the technician did carry all measures to avoid contamination (surgical mask, hand sanitizing liquid). Some participants stated that they considered the activity not that motivating to them to take any risk.

Several benefits were expected out of this first pilot. First, it would be the first application of uCARe concepts to collect data and first pilot experiences. Important aim was to do a benchmarking of models in offline mode including the uCARe tool not needed to be in its final, user friendly version, but also PHEM, Cruise and Velodyn. In addition, it would explore the recruitment of drivers in uCARe for the specific but also for further activities. In addition, more interviews with drivers’ experience would be collected. Most importantly this first experience and material collected would help involving more stakeholders and more pilots to run. The existence of this first experience would enable the discussion with more stakeholders using real world material and prove of feasibility of the proposed concepts.

Additional useful outcomes should be noted. From the total of 15 drivers that participated in the uCARe first real-world activity there was one that agreed to install the simple recording device on his vehicle’s OBD data port. The vehicle of the single volunteer was incompatible with OBD data recorder (MY: 2003) which should be noted as a restriction in such future activity. In addition, working with local UNESCO club allows to use their contact list to attract drivers that will accept installing equipment prior to joining a next event.

Other important conclusions need to be noted. Drivers being interested in uCARe does not necessarily mean that they would ever participate in a pilot programme or citizen science exercise. An application or device giving results onboard the vehicle would trigger interest to install and use uCARe equipment. Equipment and/or applications should be as simple as possible and require as little as possible driver intervention and input. Finally, willingness of drivers to install equipment on their vehicles should be secured prior to starting any activity in order to minimize the risk of failure.

All observations and experiences collected during this unsuccessful first pilot will be taken into account in future pilot activities within uCARe.
3 Pilot 2: Assessment of driving performance metrics derived using the first version of the uCARe tool on data collected with different driving styles

3.1 Introduction

As mentioned before, this first version of the report includes data derived from testing activities performed as a substitute to data that was not possible to collect so far during pilots within uCARe. Three different driving styles were analysed and compared in this report. A petrol/CNG bi-fuel passenger vehicle has been used with available independent measurements for each fuel. This allows comparison of both the effect of driving style and fuel on emissions as well as uCARe tool performance.

The different driving styles were defined from the journey’s average product of vehicle velocity and positive acceleration value. The three driving styles that are differentiated in terms of this measure are referred to from now on as:

- **REG** Regular, the route was driven within the specifications of RDE (real driving emissions) testing regulation
- **DYN** Dynamic, the route was driven just below the upper limit of the specifications of RDE testing regulation
- **eDYN** Extra-dynamic: the route was driven above the upper limit of the specifications of RDE testing regulation

Simulations were performed with uCARe tool v13.0.3.23_uCARe_V1 which was developed on the basis of PHEM model [3]. The uCARe emission maps that were produced using the map generating python script of uCARe, contain all available data for each fuel. Comparisons between the simulation and the measurement results for every driving style and fuel used are presented. A detailed section showing the input files which were used is also included.

An additional benefit from this deviation was the fact that the specific cars were also equipped with portable emission measurement equipment (PEMS) and therefore the actual measured emission performance was already known on a second by second basis. Furthermore, the uCARe emission calculation tool was made available by that time, allowing evaluation of the data using this tool.

As a result, despite the deviation from the initial plan, this report provides valuable information, in line with the initial targets that include:

- the evaluation of the effect of different driving profiles on vehicle emission performance
- the evaluation of the uCARe emission tool against reference measurement equipment
- a first assessment of the effect of driving style on a mission performance to be provided to WP4

3.2 Methodology

After the failure of the first pilot, it was decided to use data collected over other activities that include trips driven over the same route and under similar traffic conditions following different driving profiles, from mild to normal up to aggressive driving style.

3.2.1 Vehicle and drivers

The vehicle used is a bi-fuel VW Polo TGI with the following characteristics.
Table 1: Test vehicle information

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>VW</td>
<td>-</td>
</tr>
<tr>
<td>Engine displacement</td>
<td>999</td>
<td>cc</td>
</tr>
<tr>
<td>Fuel</td>
<td>Petrol / CNG</td>
<td>-</td>
</tr>
<tr>
<td>Euro cat.</td>
<td>6d temp</td>
<td>-</td>
</tr>
<tr>
<td>Year</td>
<td>2019</td>
<td>-</td>
</tr>
<tr>
<td>Mileage</td>
<td>3107</td>
<td>km</td>
</tr>
<tr>
<td>Power</td>
<td>66</td>
<td>kW</td>
</tr>
<tr>
<td>Taxonomy code</td>
<td>C—P_6_999_66_VAG</td>
<td>-</td>
</tr>
</tbody>
</table>

Professional test drivers were used for the tests. The drivers are trained to follow instructions as regards driving dynamics and traffic following. It has to be noted that the drivers used did not operate vehicles in any way not possible to be followed by normal drivers in terms of use of vehicles controls or traffic attendance techniques.

3.2.2 Driving dynamics specifications and route

As mentioned before, three different styles were used within the same route, REG, DYN and eDYN. The following figure illustrates their differences in terms of driving dynamics.

![Figure 1: Velocity multiplied by positive acceleration and driving styles](image)

These three specific driving cycles included in the figure above are the ones used in both the petrol and CNG operation case. The route elevation together with the velocity profile is also provided. It should be noted that elevation shows a significant increase. The velocity profile shown is the Petrol REG cycle.
3.2.3 Data input description
The context as to which data was used as input in the uCARe tool is presented below.

- **.veh parameters**
  In the .veh file the parameters shown in Figure 3 have been set.

- **.mep file**
  In the .mep file map the default “PC_EU6d-Temp_G.mep” map for Euro 6d Petrol vehicles has been used
• **.fld file**
   In the .fld file the default “PC_EU6d-Temp_G.fld” file for Euro 6d Petrol vehicles has been used.

• **.dri file**
   For each driving cycle the following second by second template was used:

   ![Figure 4: .dri file template](image)

• **uCARe maps**
   The amount of data and CO, NOx emissions are presented below (maps as submitted in uCARe):

   **Amount of data per bin and CO emissions for Petrol**

   ![Amount of data per bin](image)  
   ![Average CO emission](image)  
   ![Amount of data per bin](image)  
   ![Average CO emission](image)
Amount of data per bin and NOx emissions for **Petrol**

![Graphs showing NOx emissions versus engine speed and vehicle speed for Petrol.](image)

Amount of data per bin and CO emissions for **CNG**

![Graphs showing CO emissions versus engine speed and vehicle speed for CNG.](image)
Amount of data per bin and NOx emissions for **CNG**
The above indicate that although not the same amount for all cases, there are sufficient data in all maps. The available driving cycles from which these maps were generated are as follows:

<table>
<thead>
<tr>
<th>Table 2: Number of available cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>REG</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>Petrol</td>
</tr>
<tr>
<td>CNG</td>
</tr>
</tbody>
</table>

It is worth noting that CNG maps contain more data therefore they are of higher density. In addition, the DirectRPM.1Hz file has been used as output to make the comparison.

### 3.3 Results and discussion

The measurement and simulation results are presented below as follows:
- Time resolved g/s comparison
- Time resolved error
- Cumulative emissions
- Correlation of measurement vs. simulation
- Average mg/km comparison

For clarification the simulations that are included are:

<table>
<thead>
<tr>
<th>Table 3: Available simulations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vehicle</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>VW Polo TGI (CNG bi-fuel)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>VW Polo TGI (CNG bi-fuel)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

It should be noted that:
- Due to the fact that some measurements are done in cold-start mode and cold-start modelling is disabled in the specific early version of the uCARe tool, 300 s were removed in the beginning of each measurement to ensure that only hot operation is included.
- NOx simulation results for petrol present an offset of about 0.002 mg/s, thus a correction has been applied on the second by second and cumulative graphs.
3.3.1 Comparison of emission performance in g/km

3.3.1.1 Petrol g/km comparison

The simulation gram/km values have been extracted from the .res file and the DirectRPM row from within the uCARe tool results and refer to the emission performance over the complete driving route of the vehicle.

![CO and NOx comparison graphs](image)

**Figure 5**: Petrol gram per kilometre comparison
3.3.1.2 CNG g/km comparison

**Figure 6:** CNG gram per kilometre comparison
3.3.2 Correlations
3.3.2.1 Correlations petrol emissions

**Figure 7**: Correlations Petrol
3.3.2.2 Correlations CNG emissions

**CO (CNG)**

**NOx (CNG)**

**Figure 8**: Correlations CNG
3.3.3 Cumulative results

3.3.3.1 Cumulative petrol emissions

**CO (petrol)**

**NOx (petrol)**

**NOx corrected (petrol)**

(simulation = simulation - 0,002 g/s)
3.3.3.2 Cumulative CNG emissions

**Figure 9:** Cumulative Petrol emissions

**Figure 10:** Cumulative CNG emissions
3.3.4 Conclusions

Based on the results presented in the previous chapters it can be said that:

- Since there may be a time offset between measurement and simulation, all assessments were performed on a moving average basis, minimizing thus the effect of time misalignment of signals.
- In general, simulation leads to higher emissions compared to measurement for both CO and NOx.
- As regards NOx emissions, simulation results deviation gets lower as driving dynamics increase for both petrol and CNG operation. This results in convergence of simulation and measurement for NOx in petrol operation at the highly dynamic eDYN conditions. This though cannot lead to the conclusion that model performance improves when driving dynamics are increased since it may be one of several factors resulting in the specific observation.
- The difference of simulation and measurement at REG and DYN conditions is similar.
- Interestingly, simulation predicts accurately the expected trend of emissions increasing as driving dynamics increase. (Figure 9, Figure 10).
- On the other hand, CO emissions in petrol operation at the low dynamics REG(RDE) cycles are higher compared to other cycles. This may be the result of lower catalyst temperature due to lower cycle dynamics leading to reduced CO conversion efficiency.

The following are proposed:

- Cold start effect should be added in the model and further explored as regards its effect on simulation accuracy. Although 300 s were removed from the beginning of each measurement, there may some remaining catalyst temperature effect affecting the results.
- The fact that deviation of NOx emissions in petrol operation between simulation and measurement gets zero at the highly dynamic eDYN operation should be further explored.
- Model behaviour and performance will be further explored over a wider range of vehicles to arrive to safe conclusions as regards:
  - the accuracy of the model
  - the effect of driving style on emissions.

From the outcome of the use of the first version of the uCARe tool it is concluded that the uCARe tool is able to fulfil the needs of uCARe that is the simulation of the emission performance of vehicles using vehicle operation data possible to be derived from the standard OBD data port available in all vehicles in the market. Although the accuracy of the outcome is limited, it is already sufficient for providing an insight on the effects of improved driving have on the reduction of emissions produced by vehicles. The uCARe tool being in its first version, it is any way planned to have an improved version as more modules and data are added. In addition, further improvement is expected to be introduced by exploring the open issues revealed in the first assessment activity.
4 Pilot 3: Change of environmental performance after education of drivers in synergy with MILE21

4.1 Introduction

As already discussed earlier in this report, Pilot 1 in Serres failed to deliver the expected data and produce the first example of a complete application of uCARe methods and tools in real world. Given the restrictions of the current COVID-19 pandemic and in order to secure a first real-world pilot, it was decided to seek for synergies with already running projects. Such a project is MILE21, a project co-financed by the LIFE+ program of the European Union, agreement number: LIFE17 GIC/GR/000128.

MILE21 means ‘More information less emissions, Empowering Consumers for a Greener 21st Century’ and aims to provide consumers with real cars fuel consumption data and to help consumers in making well-informed purchase decisions for more efficient vehicles.

Within MILE21 drivers have already been employed in installing equipment on their vehicles to collect data in real world operation. Since this is similar to the aims of Pilot 1, it was decided to explore a synergy in order to use the same drivers and vehicle sample for the purposes of the uCARe project.

Since AUTh and TNO are partners in both uCARe and MILE21, the synergy was already agreed, set and included in the uCARe structure.

The synergy already started and is expected to provide first results by end of January 2021.

4.2 Methodology

Within MILE21 there is a number of drivers already driving in real world and collecting data of vehicle operation using simple onboard equipment.

Since the aim of MILE21 is to collect data in an as-is situation, drivers are not advised to modify their driving habits in any way. Therefore, the data of this phase will serve as a baseline for uCARe. Upon completion of data collection for MILE21, drivers will undergo training for uCARe emission reducing techniques and continue driving to evaluate the gradual improvement of the emission performance of their vehicles.

In parallel, material is being prepared within uCARe to collect vehicle status at the different phases of their involvement in uCARe.

An overview of the steps taken within this synergy is as follows:

- **Step 1, collection of baseline driving vehicle operation**: Vehicle operation data are collected from drivers following their normal driving and vehicle handling habits over their usual car use (AUTh). Collection of data is performed using a permanent in-vehicle OBD data recording device which is transparent to the drivers (not influencing vehicle ergonomics, operation or driver comfort).
- **Step 2, initial survey on drivers’ baseline**: Upon completion of step 1 drivers will undergo a survey compiled by VTI to assess their current status in terms of driving and vehicle handling.
- **Step 3, education of drivers**: Drivers will be educated using uCARe educational material on ways to improve emissions by methods related to vehicle use and handling (VTI, UnLe, LAT)
- **Step 4, survey on drivers’ perception of educational material**: This step will explore the perception of drivers on education material and the possibility to adopt each of the measures (VTI). This step will also act as a check to ensure comprehension and uptake. In case extended failure of the material to educate and convince drivers is observed, training material will be revised and step 3 revisited.
- **Step 5, collection of revised driving vehicle operation**: Vehicle operation data are collected from drivers following revised driving and vehicle handling habits over their usual car use that is expected to result in emission reduction (AUTh). Collection
of data is performed using permanent in-vehicle OBD data recording device which is transparent to the drivers (not influencing vehicle ergonomics, operation or driver comfort).

- **Step 6. survey** on drivers’ uptake of new way of driving and vehicle usage: This step will explore the gradual effect of uCARe training on changes in driving and vehicle handling habits (VTI, UnLe). This step will be performed as frequently as needed in order to gain perception of how drivers are adapting themselves to new habits.

- **Step 7. final survey** on drivers’ uptake of new way of driving and vehicle usage: This step will explore the gradual effect of uCARe training on changes in driving and vehicle handling habits (VTI, UnLe). This step will be performed as frequently as needed in order to gain perception of how drivers are adapting themselves to new habits.

All data will be collected automatically via remote connection and evaluated offline using emission modelling tools developed within uCARe.

In the end of the activity drivers will be informed on the effectiveness of the whole activity.

### 4.3 Results and discussion

No results have been produced so far since at the time of completion of this report, the MILE21 fleet was still running at the as-is situation. First results are expected to be available by end of January 2021 with data processing and more data to follow.
5 Appendix

5.1 Additional emission results from measurement and simulations

5.1.1 Petrol

5.1.1.1 Petrol REG

Figure 11: Petrol REG CO second by second comparison

Figure 12: Petrol REG NOx second by second comparison
5.1.1.2 Petrol DYN

**Figure 13:** Petrol DYN CO second by second comparison

**Figure 14:** Petrol DYN NOx second by second comparison
5.1.1.3 Petrol eDYN

Figure 15: Petrol eDYN CO second by second comparison

Figure 16: Petrol eDYN NOx second by second comparison
5.1.2 CNG

5.1.2.1 CNG REG

Figure 17: CNG REG CO second by second comparison

Figure 18: CNG REG NOx second by second comparison
5.1.2.2 CNG DYN

**Figure 19:** CNG DYN CO second by second comparison

**Figure 20:** CNG DYN NOx second by second comparison
5.1.2.3 CNG eDYN

![Figure 21: CNG eDYN CO second by second comparison](image1)

![Figure 22: CNG eDYN NOx second by second comparison](image2)
References


